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**GB 1337163 A GB 1313226 A EP 0187073 A1**

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(54) **Recording and playback apparatus**

(57) A record carrying a series of items can have recorded on it by a user instructions which, whenever the record is played back thereafter, determine the selection of items preferred by the user and their sequence of play. The record is preferably an erasable optical disc. A number of users of the same record can record personal selection/sequence instructions associated with a user code. Any selected item may be repeated in a sequence. The instructions may be recorded using the Q subcode in the compact disc format.

Fig. 1.

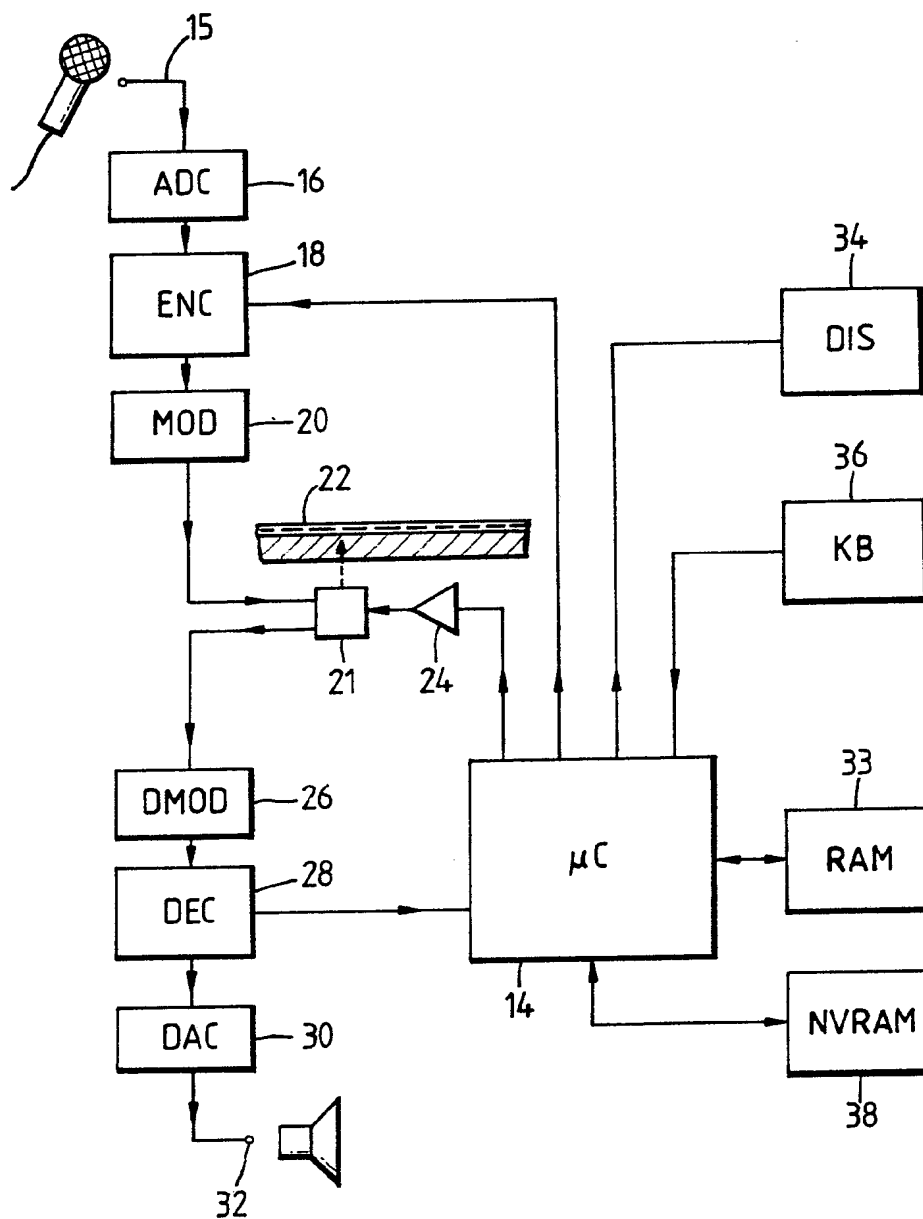


Fig. 2.

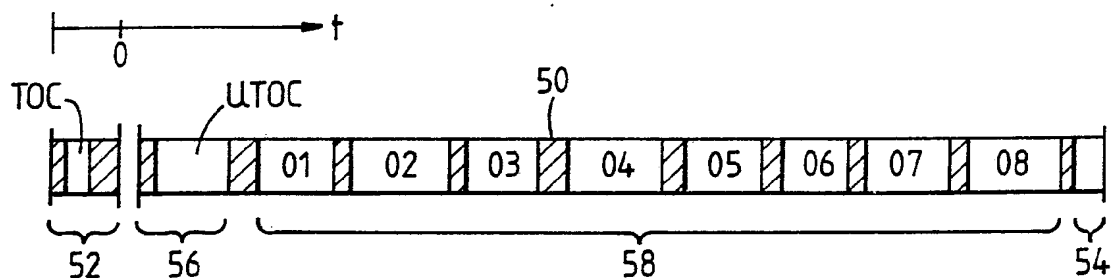
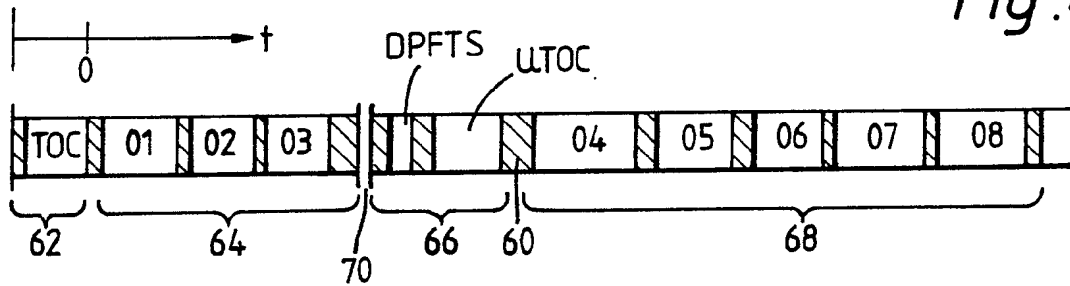


Fig. 3.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	←Q
00 ⋮	A3 ⋮	xx ⋮	xx ⋮	xx ⋮	xx ⋮	01 ⋮	00 ⋮	35 ⋮	TOC
00 ⋮	B0 ⋮	xx ⋮	xx ⋮	xx ⋮	xx ⋮	01 ⋮	xx ⋮	xx ⋮	UTOC
00 ⋮	B1 ⋮	xx ⋮	xx ⋮	xx ⋮	xx ⋮	08 ⋮	xx ⋮	xx ⋮	
00 ⋮	B2 ⋮	xx ⋮	xx ⋮	xx ⋮	xx ⋮	61 ⋮	20 ⋮	54 ⋮	
00 ⋮	01 ⋮	06 ⋮	01 ⋮	47 ⋮	01111111 ⋮	02 ⋮	02 ⋮	00 ⋮	
00 ⋮	02 ⋮	12 ⋮	58 ⋮	25 ⋮	00000101 ⋮	06 ⋮	05 ⋮	07 ⋮	
00 ⋮	03 ⋮	17 ⋮	02 ⋮	64 ⋮	00000110 ⋮	13 ⋮	04 ⋮	65 ⋮	
00 ⋮	04 ⋮	22 ⋮	12 ⋮	65 ⋮	11111111 ⋮	18 ⋮	23 ⋮	43 ⋮	
00 ⋮	05 ⋮	31 ⋮	04 ⋮	17 ⋮	10000001 ⋮	24 ⋮	11 ⋮	20 ⋮	
00 ⋮	06 ⋮	35 ⋮	42 ⋮	28 ⋮	10000010 ⋮	31 ⋮	10 ⋮	64 ⋮	
00 ⋮	07 ⋮	49 ⋮	20 ⋮	12 ⋮	00000011 ⋮	43 ⋮	51 ⋮	37 ⋮	
00 ⋮	08 ⋮	54 ⋮	09 ⋮	65 ⋮	00000100 ⋮	49 ⋮	25 ⋮	18 ⋮	

Fig. 4.



Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
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 ← Q Fig. 5.

00	01	06	01	47	00	03	02	00	} TOC
00	02	12	58	25	00	06	05	07	
00	03	16	02	64	00	13	04	65	
00	A0	xx	xx	xx	00	01	xx	xx	
00	A1	xx	xx	xx	00	03	xx	xx	
00	A2	xx	xx	xx	00	61	20	54	
00	A3	xx	xx	xx	00	17	20	35	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
00	D0	01	AA	05	06	07	08	02	} DPFTS
00	D1	03	07	08	FF	xx	xx	xx	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	} UTOC
00	B0	xx	xx	xx	xx	04	xx	xx	
00	B1	xx	xx	xx	xx	08	xx	xx	
00	B2	xx	xx	xx	xx	61	20	54	
00	B3	xx	xx	xx	xx	16	30	05	
00	04	22	12	65	80	18	23	43	
00	05	31	04	17	80	24	11	20	
00	06	35	42	28	80	31	10	64	
00	07	49	20	12	00	43	51	37	
00	08	54	09	65	00	49	25	18	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	

## Description

REPRODUCING AND/OR RECORDING APPARATUS

The invention relates to an apparatus for reproducing items of information which are recorded on a record carrier in accordance with a first time sequence.

The invention also relates to an apparatus for recording information on a record carrier, and to a combined recording and reproducing apparatus.

Apparatus for reproducing items of information which are recorded on a record carrier in accordance with a first time sequence is known for example in the form of a Compact-Disc Digital Audio (CD-DA) player, the record carrier in that case being an optically readable disc containing coded digital data representing an audio signal. The audio information is stored in a continuous time sequence along a spiral track, but parts of the recording can be identified conveniently by means of a subcode stored on the disc in parallel with the audio data. The subcode indicates during playback a current track number (for example to identify a single piece of music), an index (identifying a smaller section within a track) and values giving elapsed time from the start of the disc (absolute time) and from the start of the track (relative time).

Codes capable of identifying the items referred to in the opening paragraph can be entered by a user via a key pad to select individual items to be played. The codes may identify the items either by track number, by track number plus index or by specifying elapsed time coordinates. These three options offer successively increasing freedom in choosing the items to be played, but at the cost of increased complexity of operation for the user and a more expensive player.

There is a continuing demand for features in such equipment which allow the user more freedom to control the operation of the player. Consequently, some players incorporate features such as a program memory so that the user can select a number of items in advance. Such features are provided in recognition of the fact that users will often not wish to hear all of the items recorded on

the record carrier and/or may wish to reproduce them in a different order to that in which they are recorded.

At a further level of sophistication N.V. Philips' Gloeilampenfabrieken have produced CD-DA players incorporating features which are designated "Favourite Track Selection" or FTS. One example is available under type number CD-650 and allows a user's preferred list of track numbers to be stored for each of a number of different records. The FTS feature is described in detail in EP-A-0169597 (PHN 11078), but in summary, the known player with FTS has a non-volatile memory in which it stores the user's preferred lists of track numbers for a number of record carriers (Compact Discs). Each list has a header containing a code made by selecting arbitrary bytes from the data stored on the disc. For all practical purposes, the code is unique to each recording and is used to identify whether a disc loaded into the player is one for which a preferred sequence has been stored. Thus the user, whose favourite tracks on a particular pre-recorded disc will generally not change from day to day can hear the preferred sequence of tracks every time he/she plays the disc without having to re-program the sequence every time.

While the programming facilities have been described above in the context of Compact-Disc Digital Audio, it will be appreciated that such facilities can be provided for users of any recording medium where the player can access items from different parts of the record at random, including audio and video recording media. This is particularly the case with digital recording systems where time codes or other address information are recorded automatically with the signal data.

Whereas the present Compact Disc digital audio (CD-DA) system does not provide for users to record their own programme material onto an optical disc, there are other systems where the apparatus comprises recording and reproducing means. The best-known examples are magnetic tape cassette recorders for analogue audio and video recording, but there is also the newly-available Digital Audio Tape (DAT), digital video recording and erasable Compact Disc.

It is an aim of the invention to further increase the freedom of users to control the reproduction of information recorded on information carriers, particularly in the field of audio and video reproducing equipment for consumers.

5       The invention provides an apparatus for reproducing items of information which are recorded on a record carrier in accordance with a first time sequence, the apparatus comprising means for reading from part of the record carrier information defining a user's preferred time sequence for the items recorded on that  
10       record carrier and means for reproducing the recorded items in accordance with the preferred time sequence.

      The invention further provides an apparatus for recording information on a record carrier, the apparatus comprising input means for enabling a user to enter information defining a preferred  
15       time sequence for the reproduction of items of information which are recorded on a given record carrier in accordance with a different time sequence and means for writing information defining the preferred reproduction time sequence on a part of the given  
20       record carrier so that the information defining the preferred reproduction time sequence can be read and used to reproduce the recorded items in accordance with the preferred sequence at a later time by a reproducing apparatus as set forth in the preceding paragraph. The user of such apparatus is able to reproduce the items of information stored on the record carrier automatically in  
25       accordance with his/her preferred sequence.

      This is particularly advantageous when used with home-made recordings, because in that case the items may have been recorded individually over a period of time from different sources, and some items may have been erased and new ones recorded at a later date.  
30       Thus the items on a home-recorded carrier may end up disposed substantially at random within the first time sequence, and perhaps with large gaps in between them. The invention enables the order of reproduction to be chosen with complete freedom so as to enable a logical and pleasing sequence to be obtained, even though the  
35       order in which items are recorded may be dictated by the

availability of the source of the recording, or may be chosen in order to make efficient use of the space on the carrier.

5 In commercially produced, pre-recorded carriers, the record producers will generally have taken some care in selecting the sequence of items recorded. However users still have a desire to program their own sequences. Provided that pre-recorded material is provided on record carriers that are writable at least in part, the invention provides a facility having the same effect as FTS in the known apparatus but which has substantial advantages over the known system. Any reproducing apparatus in accordance with the invention can read the information defining the preferred sequence from a record carrier even though that information was written by a different (but compatible) apparatus, situated perhaps in a different part of the house, or in a friend's house. This forms a  
10 substantial improvement over the known FTS system, where the user's preferred selection is stored only within the player on which it was programmed.

In a reproducing apparatus in accordance with the invention, the reading means may be arranged to read the information defining the preferred sequence from a predetermined area of the record carrier distinct from the area where the items of information are recorded. The reproducing apparatus can be constructed to read the predetermined area of the record carrier automatically when a carrier is loaded, and can thus always find the information  
20 defining the preferred sequence without having to search among the recorded items themselves. Also, the preferred sequence can then be changed without disturbing the recorded items.

In such a reproducing apparatus the reading means may be arranged to read the information defining the preferred sequence as part of a table of contents identifying and locating the items recorded on the record carrier. Thus the position (if any) of each item in the preferred sequence can be read along with information enabling the apparatus to locate the item on the carrier.

30 Alternatively, the reading means may be arranged to read the information defining the preferred sequence from a part of the



said predetermined area distinct from a part containing a table of contents identifying and locating the items recorded on the record carrier. Such an arrangement has the advantage that the preferred sequence can be changed without having to re-write the table of contents on the record carrier. Rewriting the table of contents may take a relatively long time if there are a large number of items listed, for example, and may cause the introduction of errors. The information defining the preferred sequence may comprise a list of track numbers, the means for reproducing the stored items being arranged to use the list in conjunction with the table of contents in order to locate the position on the record carrier of the items in the preferred sequence. This ensures that the preferred sequence is compactly represented, so that it may be entered, written or erased relatively quickly.

In a reproducing apparatus in accordance with the invention, the means for reproducing the recorded items may comprise means for reading information recorded in a first information channel on the record carrier, and the means for reading the information defining the preferred sequence may comprise means for reading information recorded in a second information channel. Each channel can be optimised for its purpose. The first channel may be the data channel of an audio and/or video recording and the second channel may be a subcode channel recorded in parallel with the data channel. For example in the Compact Disc and Digital Audio Tape systems digital "subcode" information is recorded in parallel with the audio data for control functions, and is also used in a lead-in portion of the Compact Disc to store the table of contents of conventional pre-recorded pre-mastered recordings. In video recordings, too, digital control information can be carried in parallel with the main information channel. A well known example of a subcode in a video channel is Teletext.

The apparatus may be suitable for reproducing items of information from an erasable digital optical disc. Such discs may offer CD-DA compatible recording and reproduction, with very fast access times compared with DAT.

In a CD-DA-compatible embodiment, the information defining the preferred sequence may be read from the Q-channel of the subcode. This has the advantage that existing apparatus has provision for extracting the Q-channel data and can therefore form part of an apparatus in accordance with the invention with minimal adaptation.

5 A recording apparatus in accordance with the invention may comprise means for recording items of information on a record carrier and means for writing in a predetermined area of the record carrier a table of contents identifying the recorded items and  
10 defining their position in the first time sequence. The table of contents so written can be read and used by reproducing apparatus as set forth hereinbefore. In such a recording apparatus, the writing means may be arranged to write a table of contents containing information to enable the protection of recorded items  
15 against accidental erasure. Valued recordings can thus be identified as such and protected.

Such a recording apparatus may comprise means for using the table of contents to identify and locate areas of the record carrier that are free to receive new items to be recorded. Such a  
20 feature may allow quick access to a free area, and may provide information on its length. This enables efficient use and re-use of the area of the record carrier.

The invention still further provides a combined recording and reproducing apparatus comprising a recording apparatus as set forth  
25 hereinbefore and a reproducing apparatus capable of reproducing items of information recorded on a record carrier in accordance with a preferred reproduction time sequence defined by information recorded on the record carrier by the recording apparatus.

Embodiments of the invention will now be described, by way of  
30 example, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic block diagram of a combined recording and reproducing apparatus in accordance with the present invention;

Figure 2 shows the organisation of data on a record carrier in a first embodiment of the invention;

35 Figure 3 shows in more detail of part of the data stored in

the embodiment of Figure 2;

Figure 4 shows the organisation of data on a record carrier in a second embodiment of the invention; and

Figure 5 shows in more detail part of the data stored in the embodiment of Figure 4.

Figure 1 is a schematic block diagram of a recording and reproducing apparatus in accordance with the present invention. The invention will be described in the context of digital audio recording, by way of example only, and in particular in the context of recording on erasable optical disc, again by way of example only. Optical disc recording has advantages over tape recording in that random access to different parts of the recording is quicker. Also, erasable optical discs can use the same format and encoding techniques as the well-known Compact Disc system, ensuring compatibility with available pre-recorded discs. The format of data on Digital Audio Tape is very similar, however, so far as the information content is concerned.

The apparatus shown in Figure 1 can operate, under the control of a microcomputer 14, in either a recording (writing) mode or a reproducing (reading) mode. In the recording mode, an input 15 receives analogue audio signals (normally stereophonic) from an external source and feeds them to an analogue to digital converter (ADC) 16. The digital output of the ADC 16 is fed to an encoder 18. The microcomputer 14 supplies the encoder 18 with additional 'subcode' information, which is to be stored along with the audio data on the carrier 22.

The encoder 18 expands, interleaves and scrambles the audio data to provide error detection and correction capability. The output of the encoder 18 is fed to a modulator 20 which performs the eight-to-fourteen modulation (EFM) required to generate the pattern of marks in the spiral track of the disc. The operation of the encoder 18 and modulator 20 in the Compact Disc Digital Audio (CD-DA) System is well known and a description can be found for example in "Principles of Optical Disc Systems" by G. Bouwhuis et al, published by Adam Hilger, Bristol, UK at pages 237 et seq (ISBN

0-85274-785-3).

The stream of information generated by the modulator 20 is fed to a read/write device 21 which modifies a part of a record carrier 22 in order to store the audio and subcode data. The read/write device 21 could in fact comprise two separate devices, one for reading and one for writing, but in practice both functions can be implemented with substantially the same device, in both magnetic and optical recording.

In the case where the carrier 22 is an erasable optical disc, recording may be for example by means of the magneto-optical recording technique or by means of the phase-change technique. Magneto-optical recording is described in an article entitled "Erasable magneto-optical recording" by M. Hartmann, B. A. J. Jacobs and J. J. M. Braat in Philips Technical Review, Volume 42, No. 2 (August 1985) at pages 37 to 47. In magneto-optical recording, the read/write device 21 may be a pulsed laser and an electromagnet combined with a tracking and focussing system.

The microcomputer 14 controls the relative positions of the read/write device 21 and the carrier 22 by means of a group of actuators 24. In the case of optical disc recording, this is implemented as a number of servo mechanisms, for example for controlling the speed of rotation of the disc and the radial position (tracking) and focussing of the read/write device 21. Such systems are well known and are described fully in the reference "Principles of Optical Systems" at pages 125 et seq. If, alternatively, the carrier 22 were in the form of a tape, then the position control would be implemented primarily by means of the tape transport mechanism, together in some embodiments with a rotating head assembly.

In the reproducing (reading) mode, the read/write device 21 acts as a reading head to retrieve the data from the carrier 22. The data is passed to a demodulator 26, then to a decoder 28 and digital to analogue converter (DAC) 30 before emerging at an output 32 as an analogue audio signal. The blocks 26 to 30 thus perform

the inverse of the function of the blocks 16 to 20. The decoder 28 performs error correction and concealment functions, so that 'dropouts' caused by dust, scratches or manufacturing flaws in the disc will not be audible in the output signal.

5       The decoder 28 also separates the subcode information from the audio data and passes the subcodes to the microcomputer 14. The microcomputer 14 is thus able to detect the position of the read/write device 21 along the recorded track. The subcode in the Compact Disc Digital Audio system conveys the time elapsed from the  
10       beginning of the spiral track in minutes, seconds and frames (75 frames per second). The subcode also conveys the current track number and index, and other information about the recording.

      In order to enable the apparatus to determine in advance where on the disc to look for a given item, the subcodes are also used,  
15       during a lead-in portion of the recording, to store a table of contents (TOC) listing all the tracks recorded and their location (minutes, seconds, frames) along the spiral track. When a disc is inserted into the apparatus, the TOC is read and stored in a random access memory (RAM) 33. The subcode format and the table of  
20       contents in the CD-DA system are described fully in an article "Subcodes Explained" by J. R. Watkinson in Electronics and Wireless World magazine, September 1986 at pages 26 to 30. The embodiments of the present invention described hereinafter will comprise modifications of the CD-DA subcode format as described therein.

25       Information about the track being played and elapsed time, etc. is displayed for the user on a display 34 under control of the microcomputer 14. Information can be entered by the user via an input device 36 such as a keyboard. The information entered may include the track number, of a piece of music the user wants to  
30       hear, and the microcomputer 14 can use this information and the table of contents (TOC) stored in the RAM 33 to locate the time coordinate of the track on the record carrier and produce the desired output. Alternatively the user may enter a time coordinate directly.

35       Sequences of track numbers (or time coordinates) can be

entered and stored in the RAM so that the user can program a whole sequence of tracks to be played in turn. The apparatus is provided with the Favourite Track Selection (FTS) feature so that the user may, upon entering such a sequence, indicate that the sequence is to be stored as an FTS sequence for that record carrier. The microcomputer 14 is connected to a non-volatile memory (NVRAM) 38, for storing the identification codes and FTS sequences for non-writable record carriers (such as conventional Compact Discs) which may be in the user's collection along with writable ones. The operation of the FTS feature by the user in so far as it relates to such non-writable record carriers may be exactly as described in the first-mentioned reference, EP-A-0169597.

The operation of the FTS feature with writable discs, in accordance with the present invention can also be identical from the point of view of the user, but with the advantages of the present invention in addition. Within the apparatus, however, there are two major differences between the operation of FTS for non-writable record carriers and writable record carriers. Firstly, there is no need to generate the "fingerprint" or ID-code in order to identify which FTS sequence belongs to which record carrier : the sequence will be recorded on the carrier itself. The second difference is simply that the operations performed in the known FTS player in order to store the FTS sequences in the NVRAM are replaced by a sequence of operations to write the FTS sequence on the record carrier itself. Embodiments enabling these operations to be performed will be described hereinafter with the aid of numerical examples, with reference to Figures 2 to 5.

Figure 2 shows the organisation of data on a record carrier in a first embodiment of the invention. The record carrier in this particular embodiment is an erasable optical disc.

The information is recorded along a track 50 which in the case of an optical disc comprises a continuous spiral of marks in a recording layer of the disc. The total length of the track corresponds to a first time sequence, running from left to right as shown. In the CD-DA system, upon which this embodiment is based,

the beginning of the track is at the centre of the spiral and the end of the track is at the outer edge. If the record carrier were to be a tape, then the length of the track 50 might correspond directly to the length of the tape.

5        In a version of the Compact Disc which is both writable and erasable, it is proposed that a certain amount of information should be fixed in a spiral groove structure during manufacture of the blank discs. This information may include a time-code signal, running the entire length of the track, so that information  
10       recorded by the user can be properly located and synchronised. One method of providing a time code signal without disturbing the data channel format is to provide a pre-groove structure with a "wobble" on it, the wobble being frequency-modulated with the time code information. Such a technique is described in European Patent  
15       Application EP-A-0 265 984 (PHN 12063). For the purpose of describing the present embodiments of the invention, it is sufficient to appreciate that the absolute time coordinate is available at all points on the track, even in unrecorded portions. In accordance with the CD-DA standard, times on the disc are  
20       expressed in minutes, seconds and frames, where each second is divided into 75 frames.

      In addition to the pre-groove, the spiral track 50 is provided with a pre-mastered lead-in area 52 and a pre-mastered lead-out area 54. These areas are formed at manufacture by the same  
25       technique as conventional CD manufacture, and can be read by a conventional CD player. The pre-mastered lead-in section 52 contains information for example on the type of disc, but also includes a pre-mastered table of contents TOC.

      It will be seen hereinafter with regard to Figures 4 and 5  
30       that the premastered area can include pre-recorded items in conventional CD-DA format, but in this example, TOC simply contains a pointer to the location of a non-premastered lead-in area 56 containing a user table of contents UTOC which is both writable and erasable. Following the lead-in area 56 is the main data area 58  
35       containing the items of information (for example, pieces of music)

which are to be reproduced.

On the carrier shown, eight items or "tracks", numbered 01 to 08, are recorded along the spiral track 50. Each track 01 to 08 has a starting time and a stopping time, in minutes, seconds and frames as shown in Table 1. Thus track 01 starts at 2 minutes, 2 seconds and 0 frames and ends at 6 minutes, 1 second and 47 frames from the start of the spiral track 50, and so on. It should be appreciated that the areas shown in Figure 2 are not to scale, and that the figures used in this embodiment are by way of example only.

TABLE 1

	TRACK	START	STOP	WP	SEQ
15	01	02'02"00	06'01"47	RO	-
	02	06'05"07	12'58"25	RO	5
	03	13'04"65	17'02"64	RO	6
	04	18'23"43	22'12"65	RW	-
	05	24'11"20	31'04"17	RW	1
20	06	31'10"64	35'42"28	RW	2
	07	43'51"37	49'20"12	RO	3
	08	49'25"18	54'09"65	RO	4

Table 1 shows other information which it is desired to store within UTOC in accordance with the first embodiment of the present invention. The fourth column WP indicates whether or not each track has been write-protected. In the example, tracks 01,02,03,07 and 08 are read-only (RO), or in other words are protected against accidental erasure. Tracks 04,05 and 06 are read/write (RW), and can be erased and overwritten at will.

The fifth column, headed SEQ, defines an example of a user's preferred sequence for the tracks 01 to 08. Column SEQ for track 05 has the value 1 and so track 05 is first in the sequence, track 06 is second and so on. Thus the preferred sequence is 05-06-07-08-02-03, the tracks 01 and 04 being skipped altogether.



The information contained in Table 1 can be stored on the disc in the non-premastered lead-in area 56, within UTOC. UTOC is a modified form of the table of contents TOC defined in the CD-DA standard, as described by Wilkinson in the reference "Subcodes Explained".

In the CD-DA format, the subcode signal conveys eight 98-bit words (P-W) every frame (1/75 second). In the present case, we are concerned only with the Q-word, and further are concerned only that the Q-word can convey nine bytes of useful information in every frame.

Figure 3 shows the use of the nine bytes Q1 to Q9 of the Q-word of the subcode in the TOC and UTOC areas of the spiral track 50 described with reference to Figure 2 and Table 1. Each row in Figure 3 represents the nine bytes Q1 to Q9 of one Q-word. On the disc each word is repeated a number of times in succession, in order to ensure reliable information, because the subcode is not provided with error correction capability. This repetition occurs three times in the conventional CD-DA standard, but may be done ten times or more in an erasable system, where errors are more likely to occur.

Throughout the premastered lead-in area 52 and the non-premastered lead-in area 56 the first byte Q1 has the value 00 (hex), as described by Wilkinson. In the main data area 58, byte Q1 carries the current track number in binary-coded decimal (BCD) format. Thus there can be up to 99 tracks on a given disc.

The second byte Q2 defines the meaning of the bytes which follow. The first word shown in Figure 3, in the pre-mastered TOC area, has Q2 = A3. This defines that the bytes Q7, Q8 and Q9 of that word contain the time coordinate, in minutes, seconds and frames respectively of the start of UTOC, again in BCD format. Thus in the example, UTOC begins at a time one minute, no seconds and thirty-five frames (1'00"35) after the start of the end of the premastered lead-in area 52, which is referred to as an absolute time coordinate.

Upon reading the Q-word shown in TOC, which is always at the

start of the spiral track 50, a reproducing apparatus in accordance with the invention can locate the area UTOC on the disc and read the contents of UTOC, which identifies and locates the items recorded by the user. The first three words shown in UTOC in Figure 3 are analagous to the last three words of the TOC in the CD-DA standard. When Q2 = B0 hex, then Q7 defines the first track on the disc (01 in the example). When Q2 = B1 hex, Q7 defines the last track (08). When Q2 = B2 hex, the bytes Q7, Q8 and Q9 give the absolute time coordinate of the start of the lead-out area 54.

In the next eight words of UTOC shown, Q2 takes the value of each track number 01 to 08 recorded on the disc in turn. The bytes Q7, Q8 and Q9 of each such row define the start time of the corresponding track, as can be seen by comparison with Table 1. In the CD-DA system, the bytes Q3 to Q5 of each such entry are used to carry a running time coordinate throughout the Lead-in area. Because there is a time code encoded in the pre-groove as described hereinbefore, it is possible to use bytes Q3, Q4 and Q5 to define the stop time of each track entered in the UTOC. This enables the microcomputer software within the apparatus to calculate the location of blank areas of the disc so that new data can be recorded wherever there is space. The same function could be provided by storing the duration of each track instead of its stop time. A different technique would be to define a new track at the start of the blank area and identify it in some way as a free area. Again, software within the apparatus can identify the blank tracks as free areas for future recordings.

The byte Q6 has so far not been described and in the CD-DA standard it is defined as 00 hex and not used for any purpose. In this embodiment of the present invention, the byte Q6 is used within UTOC to convey information for the write protection and preferred sequence features. Following the example of Table 1, the most significant bit of byte Q6 in each entry in UTOC is used to define whether the corresponding track (defined in byte Q2) is read-only (Q6 = 0) or read/write (Q6 = 1). The choice of Q6 = 0 to represent a read-only track affords compatibility with conventional

CD-DA discs in which Q6 = 0, as defined by the standard. This leaves 7 bits for encoding the user's preferred sequence. It will be remembered that up to 99 tracks can be entered in the UTOC, and so up to 99 positions must be allowed in the preferred sequence.

5 This is possible in 7-bits using natural binary instead of BCD. Tracks which are to be skipped completely are marked by having a '1' in every one of the seven least significant bits. The values of byte Q6 for each entry in UTOC, as shown in Figure 3 can be compared with the columns WP and SEQ in Table 1 for further

10 clarification. It will be seen for example that the value of byte Q6 when byte Q2 = 03 hex is 00000110 binary (06 hex), which is interpreted by the apparatus reading the disc as meaning that track 03 is read-only and is sixth in the preferred sequence. Similarly, track 04 (Q6 = 11111111 binary = FF hex) is read/write and is not

15 in the preferred sequence at all.

To define a preferred sequence and write it on part of a disc, the user enters a preferred list of track numbers via the input device 36 of an apparatus such as that shown in Figure 1. A replica of the area UTOC is stored in the RAM 33 at all times and

20 is modified by the microcomputer 14 to define the preferred sequence. To write the information defining the preferred sequence, the apparatus simply re-writes the area UTOC, including the special byte Q6, onto the disc, overwriting the existing area UTOC.

25 It is a feature of this first embodiment that changing the preferred sequence requires re-writing of the entire UTOC area, even if it is only the user's preferred sequence that has been changed. Given that there may be 99 entries in UTOC, and given that each entry is repeated perhaps ten times to ensure reliable

30 retrieval, re-writing the UTOC may take up to fifteen seconds in the worst case, even though 75 Q-words can be written every second.

To reproduce the recorded items in accordance with the preferred sequence, rather than the sequence in which they are recorded along the spiral track 50, the apparatus must first read

35 the area UTOC from the record carrier. This is normally done

immediately the carrier is loaded, and the contents of the area  
UTOC are stored in the RAM so that the reading head can be directed  
to the parts of the disc required without further reference to the  
lead-in area of the disc. In order to reproduce the recorded items  
5 in accordance with the preferred sequence read from the disc from  
within the area UTOC, the entries in the area UTOC are searched,  
examining the byte Q6 each time until the entry identifying the  
first item in the preferred sequence is found. The stored time  
coordinates in bytes Q7, Q8 and Q9 can then be used to locate and  
10 reproduce the item, and then the area UTOC can be searched for the  
second, third, fourth, etc. items in turn.

Figure 4 shows the organisation of data on a record carrier in  
accordance with a second embodiment of the invention. The spiral  
track 60 shown is physically similar to spiral track 50 in the  
15 first embodiment, but with two differences in the organisation of  
the information content. This second embodiment illustrates the  
provision of both pre-mastered and writable/erasable recordings on  
the same disc. The pre-mastered area in the spiral track 60  
includes a lead-in area 62 including a pre-mastered table of  
20 contents TOC and a pre-mastered main data area 64 including three  
tracks of programme material, namely tracks 01, 02 and 03.

The writable/erasable portion of the spiral track 60 comprises  
a lead-in area 66 and a main data area 68, similar to those of the  
spiral track 50 in the first embodiment, except that the lead-in  
25 area includes an area DPFTS (disc programmable favourite track  
selection) in addition to a user table of contents UTOC, as will be  
described in more detail with reference to Figure 5. The main data  
area 68 of the writable/erasable portion contains five recorded  
tracks, numbered 04 to 08 to follow on from the numbering of the  
30 pre-mastered tracks 01 to 03. The two pre-mastered and writable  
portions may be separated by a small "no-go" area 70, to avoid  
disorientation of the mechanism of a reproducing apparatus which  
might occur at an unexpected transition from one type of track  
(stamped, for example) to another (magneto-optical or phase-change,  
35 for example).

Time coordinates of the tracks 01 to 08 and their other attributes in the second embodiment are shown, by way of example only, in Table 2. The columns have the same meaning as in Table 1, and the time coordinates differ from those of the first embodiment in two cases only. The preferred sequence, defined by a user, is shown in column SEQ and is the same as that in the first example except that at the end of the sequence tracks 07 and 08 are repeated to illustrate how the second embodiment of the present invention allows the same item to feature in the preferred sequence more than once. The full preferred sequence for the tracks 01 to 08 on the spiral track 60 is thus 05-06-07-08-02-03-07-08. Write protection (column WP) is the same for the tracks 01 to 08 as in the first embodiment, although it should be appreciated that tracks 01 to 03 are inevitably read-only (RO) because they are recorded in the pre-mastered portion of the spiral track 60.

TABLE 2

	TRACK	START	STOP	WP	SEQ
20	01	03'02"00	06'01"47	RO	-
	02	06'05"07	12'58"25	RO	5
	03	13'04"65	16'02"64	RO	6
	04	18'23"43	22'12"65	RW	-
25	05	24'11"20	31'04"17	RW	1
	06	31'10"64	35'42"28	RW	2
	07	43'51"37	49'20"12	RO	3,7
	08	49'25"18	54'09"65	RO	4,8

Figure 5 shows the format of the areas TOC, DPFTS and UTOC in the spiral track 60, using the figures of Table 2 as an example. The Q-word of the Compact Disc subcode is used, as in the first embodiment and the references Q1 to Q9 will again be used for the bytes of that word. The area TOC defines the start and stop times of the pre-mastered tracks 01, 02 and 03 when byte Q2 takes the

values 01, 02 and 03 respectively. In the embodiment of Figures 4 and 5, the byte Q6 does not convey preferred sequence information, but still conveys the write-protection information. Byte Q6 takes the value 00 hex a read-only (R0) track and 80 hex for a read/write (RW) track.

The Q-words shown where the byte Q2 takes the values A0 hex and A1 hex in the area TOC, define the first and last tracks as 01 and 03 respectively; that where Q2 = A2 hex points to the lead-out area; and the Q-word having Q2 = A3 hex points to the start of the area UTOC, which is at 17'20"35 in the present example.

The area UTOC identifies and locates the remaining, non-premastered tracks 04 to 08, and defines tracks 04 and 08 as the first and last tracks in the writable/erasable portion of the spiral track 60. In this respect, the pre-mastered and writable portions of an erasable Compact Disc are organised analogously to the organisation of recordings which occupy a series of two or more separate CD-DA discs.

The area UTOC also contains the time coordinate of the area DPFTS. In the example shown, this coordinate is 16'30"05 and is written in the bytes Q7, Q8, Q9 of a Q-word marked by the value B3 in the byte Q2. The value B3 has been chosen arbitrarily from those hexadecimal values not already assigned to another function and any distinctive value or group of values could be used. The area DPFTS is placed on the spiral track 60 before the area UTOC because the latter area will normally vary in length far more than the former area, but DPFTS and UTOC could equally be stored anywhere on the disc, since the entries in TOC marked by Q2 = A3 and Q2 = B3 can point to any part of the recording.

In the area DPFTS, two Q-words (each repeated ten times for reliable reproduction) are required to define the eight tracks of the preferred sequence. The first word of DPFTS is marked by the value D0 in the byte Q2. This again is an arbitrary choice from the hexadecimal codes available. The codes D1, D2, D3 and so on can be used to identify continuations of the DPFTS area as may be required to store longer sequences.

In the byte Q3 of the first word in the area DPFTS there is space for a user number, 01 in the example shown, to be described hereinafter. The bytes which follow list the track numbers of the items in the preferred sequence, in order. The list is marked at its start by a byte having the value AA hex and marked at its end by a byte having the value FF hex. The preferred sequence is defined in exact correspondence with the sequence defined in Table 2, namely 05-06-07-08-02-03-07-08. Using all the codes D0 to DF for continuations of the list defining the preferred sequence, the preferred sequence could include more than a hundred tracks, and can include a given track more than once.

The user number, 01 in the example, can be used to identify the user whose preferred sequence is defined by the list which follows, and a preferred sequence can be defined for each of a number of users. This is in recognition of the fact that the preferred sequence is something personal to each user and different users may prefer a different sequence of tracks. In Figure 5, only one preferred sequence is defined, but further sequences could be written in the area DPFTS, with user numbers 02, 03 etc.. The same facility could also be achieved by providing a separate area DPFTS for each user. Each area DPFTS could then be identified and located by a different entry in the area UTOC, for example using the values B4, B5, B6, etc. for the byte Q2 to identify the area DPFTS for each user in turn.

To write the area DPFTS on the spiral track 60, the user operates the controls of the recording apparatus (such as that shown in Figure 1) to define the preferred sequence. This definition can be stored in RAM as a list of track numbers. When complete, the user can specify his or her user number, and instruct the apparatus to write the area DPFTS on the spiral track 60 as described.

To reproduce the recorded information, the apparatus will read the areas TOC and UTOC and store the contents in RAM, as in a normal CD player. The area DPFTS can also be read and stored in RAM or can be read only when required. To reproduce the tracks in

accordance with a preferred sequence stored on the disc, the user must specify his or her user number (if more than one user has programmed a preferred sequence on the disc) and the microcomputer within the apparatus can search the area DPFTS for that user number and retrieve the list of track numbers defining that user's preferred sequence. By using the area UTOC (normally duplicated within the RAM), the time coordinates of each track in the sequence can be found and the reading device directed to the appropriate part of the disc to reproduce each track in turn.

The second embodiment just described has advantages over the first embodiment for various reasons. Firstly, there is no need to rewrite the entire area UTOC each time the preferred sequence is changed. Second, a different preferred sequence can be defined by each of a plurality of users and written on the disc independently of those of other users. A further advantage is that a given recorded item can appear more than once in the preferred sequence.

The second embodiment is also advantageous where some items are provided on a pre-mastered, non-writable part of the disc. The preferred sequence written in accordance with the second embodiment can include or exclude the pre-mastered items as desired, whereas in the first embodiment it could not, unless the pre-mastered tracks were identified in the area UTOC as well as in the area TOC. This also makes possible the provision of disc-programmable FTS on a completely pre-mastered disc, so long as there is provided a writable/erasable portion large enough to store an area DPFTS. On such a disc, the pre-mastered table of contents TOC may contain a pointer to the area DPFTS, or there may be provided a minimal user table of contents area UTOC to maintain compatibility with the embodiment described.

It should be appreciated that the invention is substantially independent of the type of information recorded on the record carrier. The recorded items may be digital audio tracks, as described in the specific examples, but could equally be short video films (such as often accompany popular songs). In the same medium of combined audio and video, the recorded items could be



individual arias from an opera performance. It will be appreciated that the invention is generally applicable and that all specific applications described are presented by way of example only. Similarly, the organisation and format of the recorded data is a matter for design to suit the particular application and the medium used.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of reproducing and/or recording apparatus and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

## Claim(s)

1. An apparatus for reproducing items of information which are recorded on a record carrier in accordance with a first time sequence, the apparatus comprising means for reading from part of the record carrier information defining a user's preferred time sequence for the items recorded on that record carrier and means for reproducing the recorded items in accordance with the preferred time sequence.

2. An apparatus as claimed in Claim 1 wherein the reading means are arranged to read the information defining the preferred sequence from a predetermined area of the record carrier distinct from the area where the items of information are recorded.

3. An apparatus as claimed in Claim 2 wherein the reading means are arranged to read the information defining the preferred sequence as part of a table of contents identifying and locating the items recorded on the record carrier.

4. An apparatus as claimed in Claim 2 wherein the reading means are arranged to read the information defining the preferred sequence from a part of the said predetermined area distinct from a part containing a table of contents identifying and locating the items recorded on the record carrier.

5. An apparatus as claimed in Claim 4 wherein the information defining the preferred sequence comprises a list of track numbers, the means for reproducing the stored items being arranged to use the list in conjunction with the table of contents in order to locate the position on the record carrier of the items in the preferred sequence.

6. An apparatus as claimed in any preceding claim wherein the means for reproducing the recorded items comprises means for reading information recorded in a first information channel on the record carrier, and the means for reading the information defining the preferred sequence comprises means for reading information recorded in a second information channel.

7. An apparatus as claimed in Claim 6 wherein the first channel is the data channel of an audio and/or video recording

and the second channel is a subcode channel recorded in parallel with the data channel.

8. An apparatus as claimed in Claim 7, suitable for reproducing items of information from an erasable digital optical disc.

9. An apparatus as claimed in Claim 8 arranged to read information written in a format compatible with the Compact Disc Digital Audio system wherein the reading means is arranged to read the information defining the preferred sequence from the Q-channel of the subcode as defined in that system.

10. An apparatus as claimed in any preceding claim comprising means for reading information defining a preferred time sequence for each of two or more different users of the given record carrier.

11. An apparatus for recording information on a record carrier, the apparatus comprising input means for enabling a user to enter information defining a preferred time sequence for the reproduction of items of information which are recorded on a given record carrier in accordance with a different time sequence and means for writing information defining the preferred reproduction time sequence on a part of the given record carrier so that the information defining the preferred reproduction time sequence can be read and used to reproduce the recorded items in accordance with the preferred sequence at a later time by the same apparatus or an apparatus as claimed in one of the preceding claims.

12. An apparatus as claimed in Claim 11 comprising means for recording items of information on a record carrier and means for writing in a predetermined area of the record carrier a table of contents identifying the recorded items and defining their position in the first time sequence.

13. An apparatus as claimed in Claim 12 wherein the writing means are arranged to write a table of contents containing information to enable the protection of recorded items against accidental erasure.

14. An apparatus as claimed in Claim 12 comprising means for using the table of contents to identify and locate areas of the record carrier that are free to receive new items to be recorded.

5 15. A combined recording and reproducing apparatus comprising a recording apparatus as claimed in any of Claims 11 to 14 and a reproducing apparatus capable of reproducing items of information recorded on a record carrier in accordance with a preferred reproduction time sequence defined by information recorded on the record carrier by the recording apparatus.

10 16. A combined recording and reproducing apparatus as claimed in Claim 15 wherein the reproducing apparatus comprises an apparatus as claimed in any of Claims 1 to 10.

15 17. An apparatus substantially as described herein with reference to Figures 1 to 3 or to Figures 1, 4 and 5 of the accompanying drawings.

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